I. C. 7076 JUNE 1939

UNITED STATES
DEPARTMENT OF THE INTERIOR
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BUREAU OF MINES
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INFORMATION CIRCULAR

BUREAU OF MINES MIDGET IMPINGER

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BY

H. H. SCHRENK AND FLORENCE L. FEICHT

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

BUREAU OF MINES MIDGET IMPINGER[1/]

By H. H. Schrenk[2/] and Florence L. Feicht[3/]

The Bureau of Mines midget impinger dust-sampling apparatus was described first in 1937.[4/] Two supplementary reports[5/6/] were published in 1938. These reports are now out of print. The material published previously is combined in this paper to make information on this device available for distribution.

The impinger was developed by the Bureau of Mines in cooperation with the United States Public Health Service in 1922. The underlying principle of this instrument is based on impingement and wetting of the dust particles by drawing air through a nozzle at high velocity onto a smooth surface under a bubbling column of liquid. The dust particles are retained in the liquid. The apparatus has been used widely and permissible limits of dustiness have been established in the United States on the basis of results obtained with this device in correlation with medical studies. However, it has been criticized for its bulk, weight, and power requirements.

A number of devices that are easier to use have been developed. Results obtained with these, as well as with the impinger, are empirical and indicate relative dustiness rather than the absolute number of dust particles in the air. Because of the empirical nature of the procedures, different operating principles, and the variables introduced by the many types of air-borne particulate matter, the possibility of correlating the results obtained by the different instruments with impinger results does not appear very promising.

It was thought that the criticisms of the impinger could be overcome to some extent by building a more readily portable and easily operated instrument. It was also believed that a smaller instrument identical in principle and using the same counting technique should give the same results, within experimental limits.

1/ The Bureau of Mines will welcome reprinting of this paper provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7076."

2/ Chief chemist, Health Division, Bureau of Mines.

3/ Junior physicist, Gas and Dust Section, Central Experiment Station, Bureau of Mines, Pittsburgh, Pa.

4/ Littlefield, J. B., Feicht, Florence L., and Schrenk, H. H., The Bureau of Mines Midget Impinger for Dust Sampling: Rept. of Investigations 3360, Bureau of Mines, 1937, 4 pp.

5/ Littlefield, J. B., and Schrenk, H. H., Dust Sampling with the Bureau of Mines Midget Impinger, Using a New Hand Operated Pump: Rept. of Investigations 3387, Bureau of Mines, 1938, 4 pp.

6/ Littlefield, J. B., Feicht, Florence L., and Schrenk, H. H., Efficiency of Impingers for Collecting Lead Dusts and Fumes: Rept. of Investigations 3401, Bureau of Mines, 1938, 9 pp.

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With these ideas in mind, the midget impinger dust-sampling apparatus was developed by the Bureau of Mines and described in Report of Investigations 3360.7/ The device is self-contained and easily hand operated and the complete apparatus, including 6 to 10 impinger flasks in a convenient case, need not weigh more than about 10 pounds.

DESCRIPTION OF MIDGET IMPINGER FLASK

Figure 1 shows the comparative size of the large and midget impinger flasks.

Figure 2 shows the midget impinger flask, which is about 11 cm. long and 2.5 cm. in diameter. It has a side arm about 1 cm. in diameter tilted upward at an angle of 45° to facilitate dilution and cleaning. The impinger flask is graduated at 5-ml. intervals for a total of 30 ml. A mark at a point 5 mm. from the bottom serves as a guide for setting the nozzle of the impinger tube at the proper distance from the bottom. Four projections on the impinger tube near the lower end aid in holding it centrally in the flask, a desirable but not essential feature. The tube through which the air is drawn has an orifice 1 mm. in diameter. The orifice size should be controlled carefully; otherwise, separate calibrations are necessary.

One-hole Neoprene stoppers are used in the tops of the flasks. Ordinary rubber stoppers are not used because of the possibility of contamination of the impinger liquid with particulate matter. Noair rubber stoppers are satisfactory for closing the side arm, and rubber caps or "policemen" can be used for closing the inlet to the impinger.

A metal S-shaped guard is used on top of the stopper to prevent material from dropping into the intake (see fig. 2).

DESCRIPTION OF SUCTION APPARATUS

The operation of the midget impinger is identical with that of the large impinger, except that a vacuum of 12 inches of water is required, compared with 36 for the large impinger. With a 1-mm. orifice and a vacuum of 12 inches of water, the flow through the instrument is approximately 0.1 cubic foot per minute.

Any satisfactory means can be used for drawing the air through the impinger. The suction for the first midget impinger designed was supplied by a small rotary pump of the vane type operated by a hand crank through a set of gears with a ratio of 9 to 1. A check valve and surge tank were inserted between the pump and impinger to obtain a smoother flow.

Subsequently, a pump was designed especially for use with the midget impinger and gave excellent performance. It has four cylinders disposed radically at 90° about a single-throw crank. The intake valves connect to a collector ring, which in turn connects through a check valve to the first surge tank, which in turn connects to a second through a needle valve. A

7/ Work cited, see footnote 4/.

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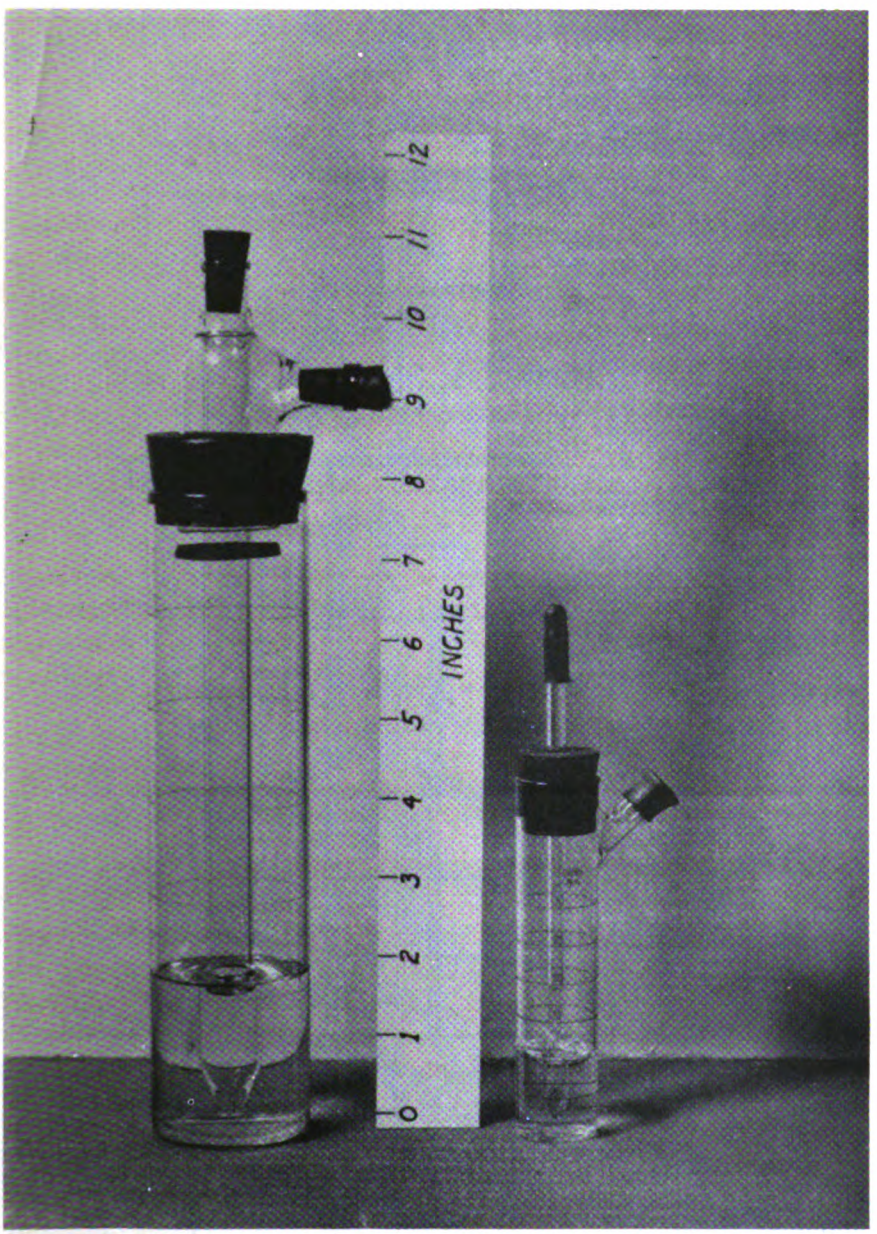

Figure 1.- Large and midget impingers.

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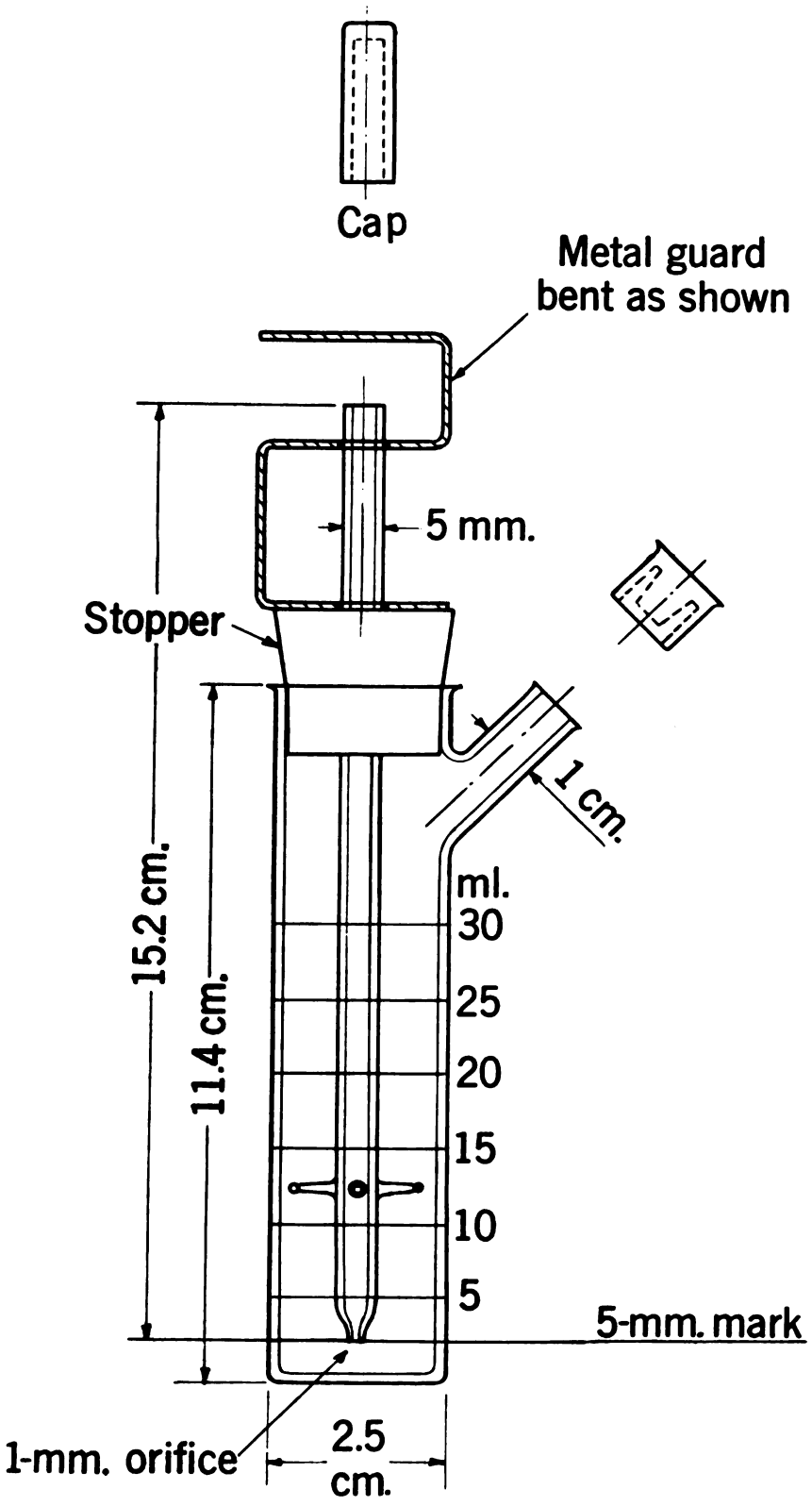

Figure 2.- Midget impinger.

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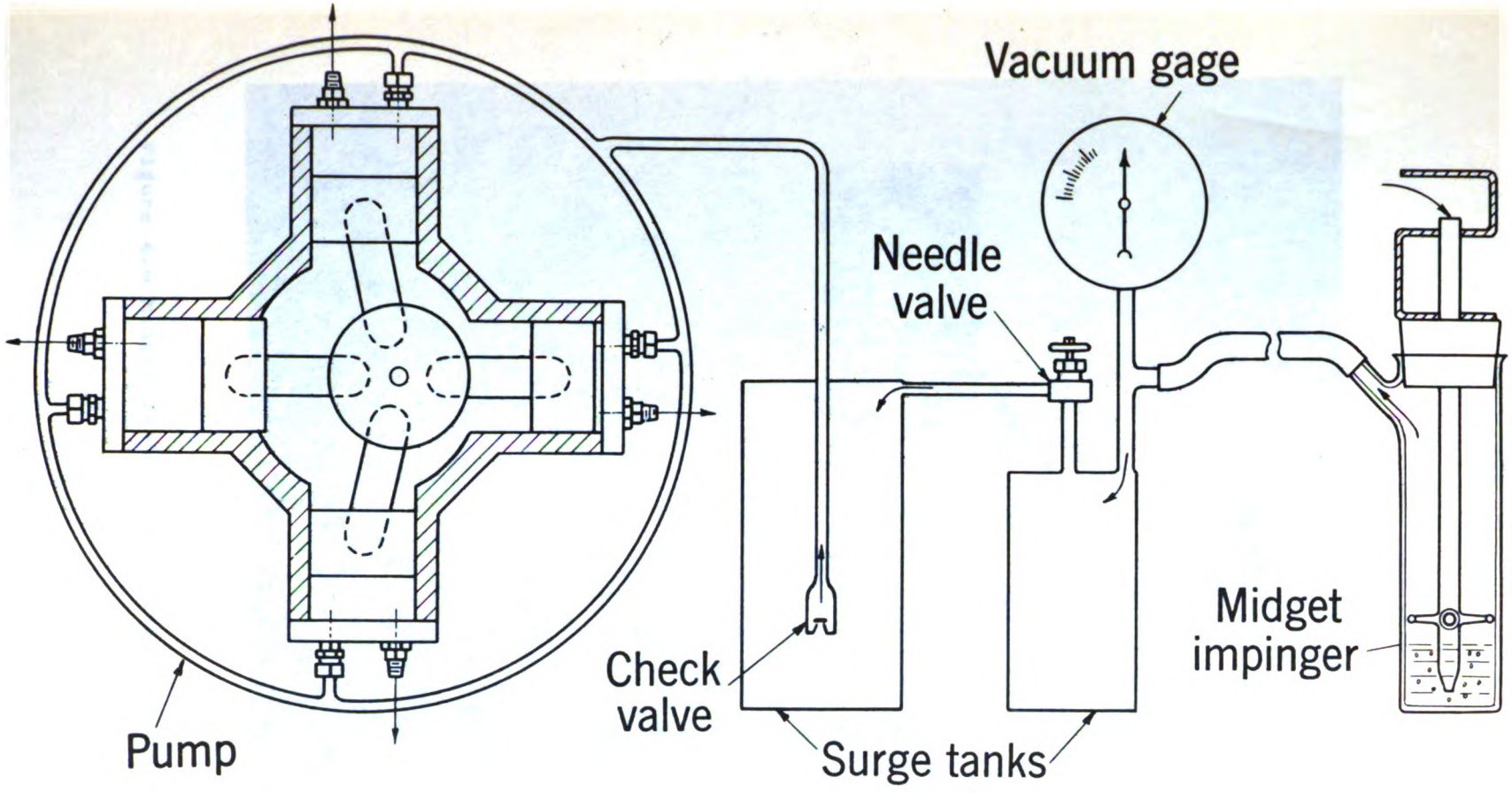

Figure 3.- Midget impinger sampling apparatus.

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Figure 4.- Midget impinger sampling apparatus.

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vacuum gage is used to indicate the suction necessary to pull through 0.1 cubic foot of air per minute. The pump is so designed that minor variations in the crank speed do not affect the flow of air significantly.

Figure 3 is a diagrammatic sketch of the impinger assembly, including the specially designed pump.

COLLECTING AND COUNTING SAMPLES

Figure 4 shows the complete midget impinger sampling apparatus in position for sampling. The case is open to show the pump, accessories, and eight extra impinger flasks. The vacuum gage is in the top. One end of the case is hung from the operator's belt by a hook and the other end is supported by a strap passing in back of the operator's neck. When not in operation, the strap may be fastened at the ends of the case and used in carrying the apparatus. Another and probably more comfortable arrangement would be to use two straps and attach them to a shoulder harness. The impinger flask is connected to the suction apparatus by a piece of 1/4-inch rubber tubing. It is then placed in the small holster and held at the sampling point.

The midget impinger flask usually is filled to the 10-ml. mark with the collecting liquid for sampling. The suspension obtained is diluted to a proper concentration for easy counting.

The samples are counted[8/] essentially as are samples collected with the large instrument.

RESULTS OF TESTS

Laboratory Studies

Silica Dust. - The midget impinger was compared with the large impinger in the laboratory. Concentrations of silica dust ranging from 0.5 to 30 million particles per cubic foot were prepared in a chamber by dispersing virtually pure SiO_2 dust at a uniform rate into an air stream. Particle-size measurements (microprojection technique) of the dust samples collected from the chamber by a thermal precipicator showed a geometric mean of 0.6 micron and a standard geometric deviation of 1.9.

Simultaneous samples were taken by the large impinger and by two midget impingers. One of the midget impingers had ground-glass joints and was operated by a large suction system; the other was equipped as shown in figure 2 and was hand-cranked. The all-glass apparatus was used in studying the possibility of errors from contamination by the stoppers.

Table 1 gives the results of the tests. The concentrations found; the ratios between the all-glass and the large impingers (G/L ratio); the ratios

8/ Brown, Carlton E., and Schrenk, H. H., A Technique for Use of the Impinger Method: Inf. Cir. 7026, Bureau of Mines, 1938, 20 pp.

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between the hand-cranked midget impinger and the large impinger (H/L); and the ratios between the all-glass and the hand-cranked midget impingers (G/H ratio) are given. The ratios of these tests show that the midget impinger checked the large impinger generally within 10 percent, a variation that might be expected when comparing two large impingers.

TABLE 1. - Comparison of midget impinger with large impinger. Silica dust disseminated in chamber.

Concentration, millions of particles per cubic foot			Ratios		
Large L	All-glass midget G	Hand-cranked midget H	G/L	H/L	G/H
0.47	0.48	0.42	1.02	0.89	1.14
.55	.55	.56	1.00	1.02	.98
1.14	1.31	1.06	1.15	.93	1.24
1.55	1.64	1.62	1.06	1.05	1.01
6.1	7.1	5.8	1.16	.95	1.22
7.9	8.1	8.0	1.02	1.01	1.01
11.4	13.1	10.6	1.15	.93	1.24
20	20	19	1.00	.95	1.05
30	29	28	.97	.93	1.03
		Average	1.06	.96	1.10

Lead Dust and Lead Fume. - The efficiency of the midget impinger for collecting lead dust and lead fume also was studied. The atmosphere containing lead dust was prepared by dispersing lead dust at a uniform rate into an air stream. The lead dust used consisted of 72 percent litharge, PbO, 25 percent red lead, Pb_3O_4, and 3 percent lamp black, a mixture used in the storage-battery industry. The lead fume was generated by burning lead tetraethyl.

Simultaneous samples were collected by the midget impinger and the electr precipitator. Various impinger liquids (water, ethyl alcohol, 5 percent nitri acid, and 10, 20, and 40 percent acetic acid) were used; however, 5 percent nitric acid was used most frequently. The electric precipitator was used as the reference method because of its efficiency for collecting dispersoids. The percent efficiency of the midget impinger was calculated on the basis that the electric precipitator was 100-percent efficient. The material collected was analyzed for lead by the chromate method.

Table 2 shows the efficiency of the midget impinger for collecting lead dust and lead fume when compared with the electric precipitator. The efficiency for lead dust ranged from 81 to 115 percent in five tests with a concentration of approximately 14 mg. of lead per cubic meter. The average recovery in the five tests was 101 percent. These results show that the midget impinger has a satisfactory collecting efficiency for lead dust. Thes tests are of particular interest, since the comparison is made on the basis o chemical analysis while the silica-dust tests were made on the count basis.

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TABLE 2. - Efficiency of midget impinger for collecting lead dust and lead fume.

Concentration, mg Pb per cubic meter		Efficiency of midget impinger, 1/ percent
Midget impinger	Electric precipitator	
	Lead dust	
13.4	13.6	99
13.7	16.9	81
14.2	15.2	93
14.2	12.6	113
14.8	12.9	115
13.7		106
		2/ 101
	Lead fume	
0.9	5.4	17
2.6	12.2	21
2.8	16.4	17
4.3	33.3	13
5.5		16
		2/ 17

1/ Electric precipitator value considered 100 percent.
2/ Average.

The efficiency of the midget impinger for lead fume ranged from 13 to 21 percent in four tests with a concentration of 5.4 to 33.3 mg. lead per cubic meter. These tests show that the midget impinger has a low efficiency for collecting lead fume. Under similar conditions the large impinger also gave low results when compared with the electric precipitator, although its efficiency was somewhat higher than that of the midget impinger.

Field Studies

Comparative tests also were conducted during rock-drilling experiments in hard and weathered Catoctin greenstone at the Test Adit of the Mining Division of the Bureau of Mines at Mt. Weather, Va., and while drilling in siliceous schist.

Catoctin Greenstone. - Table 3 gives the results of 20 tests in which simultaneous midget and large impinger samples were taken. The samples were collected during wet drilling, with the exception of the last three, which were collected while dry drilling. The results obtained with the large and midget impingers were of about the same magnitude. Several of the results with the midget impinger were somewhat lower than those of the large impinger for low concentrations of dust. As samples were collected for only 5 minutes at a time, the amount of dust collected was small. Under such conditions a small error in counting may cause a large percentage of error in the final calculated results. Samples collected for 15 minutes probably would have given better agreement.

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TABLE 3. - Comparison of midget impinger with large impinger. Dust disseminated by pneumatic drilling in Catoctin greenstone.

Concentration, millions of particles per cubic foot		Ratio,
Large impinger	Midget impinger	large/midget
3.2	7.5	0.43
4.2	3.0	1.40
5.2	4.0	1.30
5.2	5.0	1.04
5.8	6.5	.89
6.5	6.0	1.08
6.8	9.5	.72
7.8	10.0	.78
8.0	10.0	.80
8.5	8.0	1.06
9.2	8.0	1.15
9.5	8.0	1.19
10.0	7.0	1.43
10.2	14.0	.73
17.5	13.5	1.30
19.5	19.5	1.00
29.5	25.0	1.18
165	140	1.18
740	730	1.01
1,450	1,550	.94
		1/ 1.03

1/ Average.

Siliceous Schist. - Table 4 gives additional results that were obtained by a Bureau engineer who used the midget and large impingers during an investigation in which drilling was done in siliceous schist. These samples were collected over a period of 15 minutes, and even though the concentrations were very low, the agreement was as good as could be expected from two large impingers.

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TABLE 4. - Comparison of midget impinger with large impinger. Dust disseminated by pneumatic drilling in siliceous schist.

Concentration, millions of particles per cubic foot		Ratio, large/midget
large impinger	Midget impinger	
1.6	1.7	0.94
1.8	2.1	.86
2.3	2.5	.92
2.3	2.2	1.05
3.3	2.9	1.14
3.7	3.9	.95
4.9	4.5	1.09
7.5	7.9	.95
8.1	8.2	.99
10.2	10.8	.94
14.5	15.2	.95
		1/ .98

1/ Average.

SUMMARY

A light, compact, self-contained, and easily hand-operated midget impinger is described. The complete apparatus, including a number of impinger tubes in a convenient carrying case, need not weigh more than about 10 pounds. The device was tested by the Bureau of Mines against silica, Catoctin greenstone, and siliceous schist dust and gave results that agree well with those obtained with the large impinger. Satisfactory results were obtained for lead dust when compared with the electric precipitator. The efficiency of the midget as well as the large impinger for collecting lead fume was low.

The apparatus is now commercially available and a number of the devices are in use.

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